Energy transition and hydrogen

Tristan Smith + team

For more information visit:
www.u-mas.co.uk
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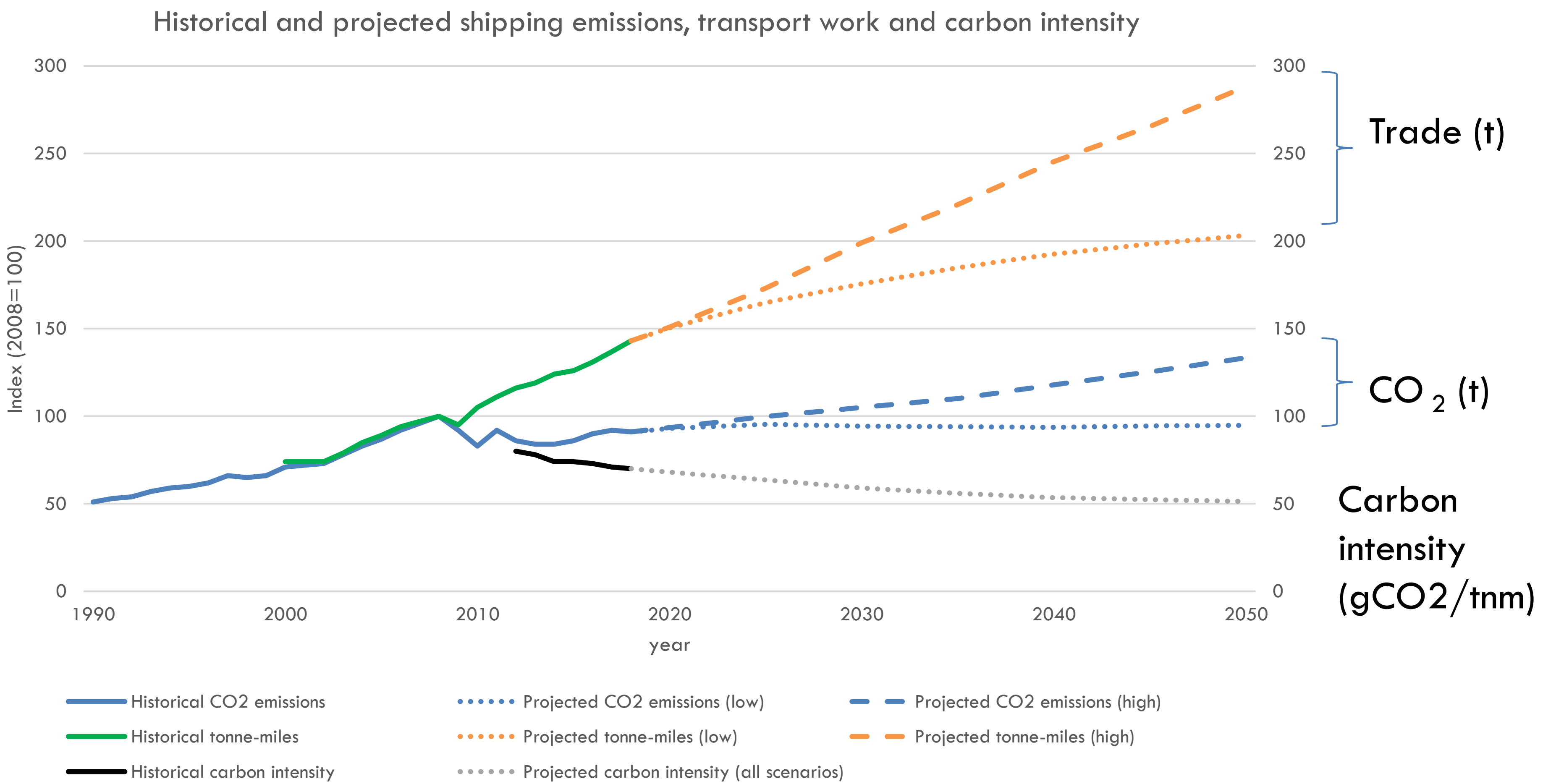
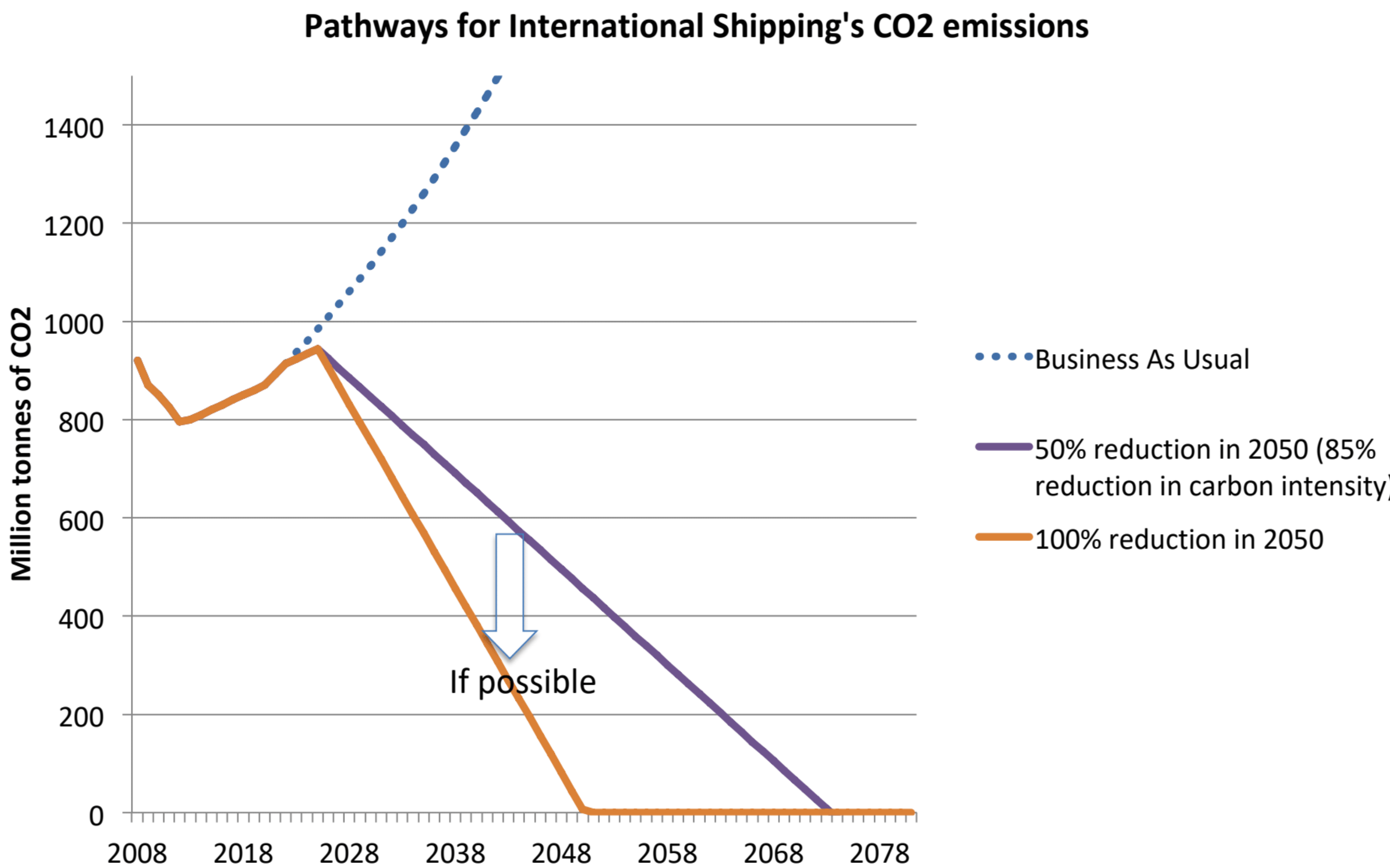
UMAS

Maritime consultancy delivering applied solutions for a carbon constrained future

Shipping CO_2 emissions, trade and carbon intensity

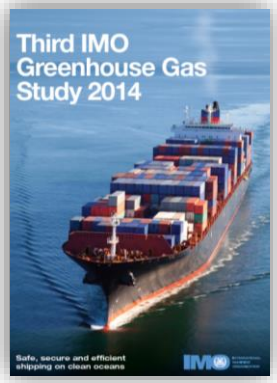


IMO Initial Strategy (April 2018)



Focus of our shipping research and consultancy work

2000's — Now — 2050



Evidence of recent trends in energy efficiency

Using big data to understand trends and drivers of shipping activity, energy demand/emissions

Evidence of how the future of energy efficiency/GHG might look

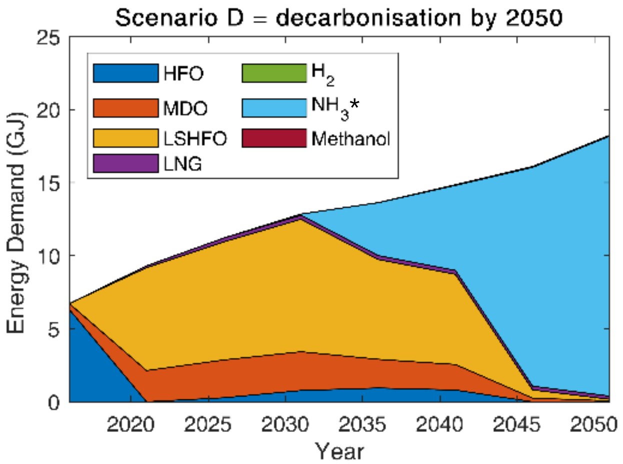
Using models to explore what-ifs for future market and policy

UMAS

Zero-emission fuel adoption 2030-2050 needs to be rapid, irrespective if the target is zero by 2050 or 2070

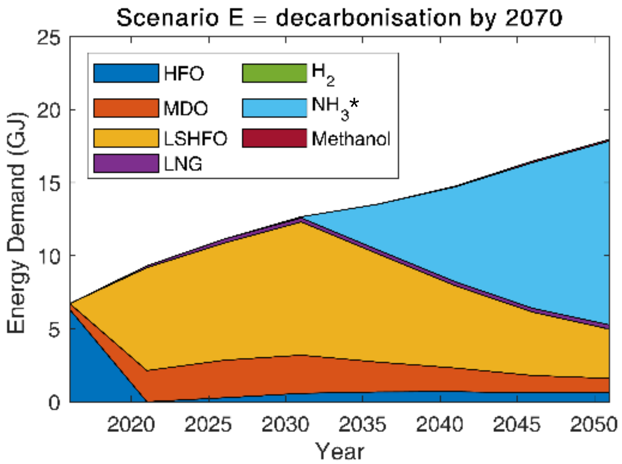
2050 decarbonization (1.5ºC aligned)

GJ



2070 decarbonization (IMO aligned)

GJ



Graphs show optimal fuel mix reached in analysis of several candidate zero emission fuels for UK's Clean Maritime Plan in 2019

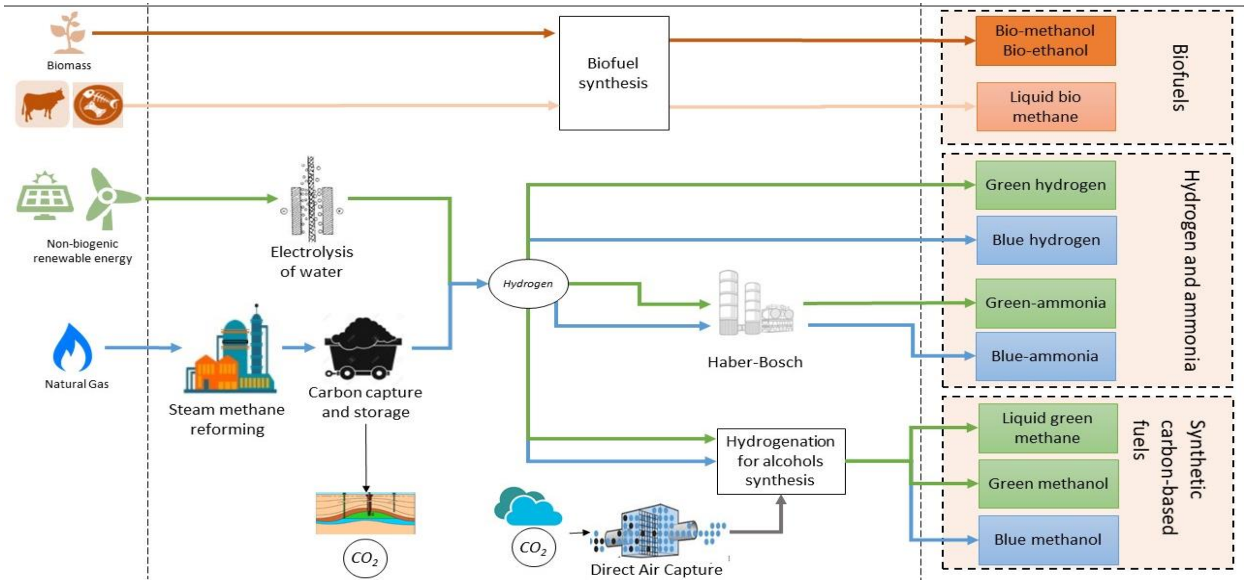
Source: UMAS GloTraM (2019), UK Clean Maritime Plan

Total cost of operation

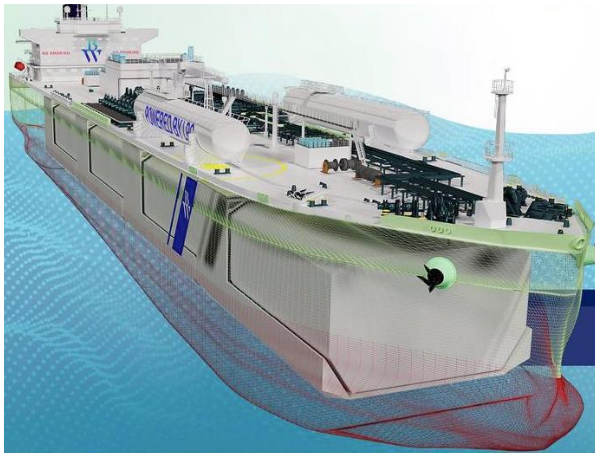
Feedstock prices

Production process capex/opex/efficiency

Machinery and storage, capex, efficiency, size



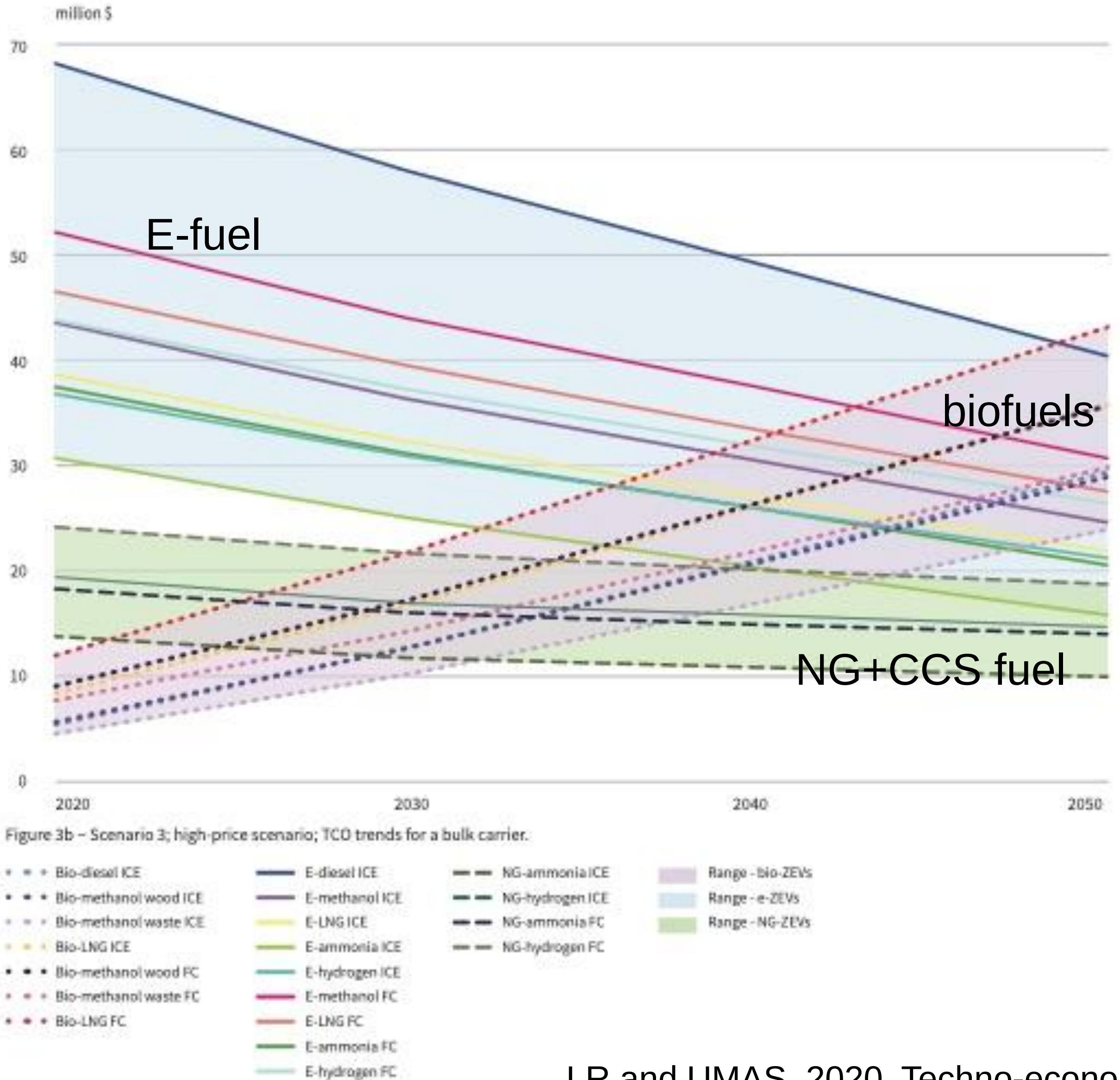
UMAS and World Bank forthcoming



BW

= additional fuel cost + additional capital cost of mcy + additional capital cost of storage - lost capacity (revenue)

High price scenario, 80,000dwt bulk carrier, total annual additional cost



Biofuel increases in price

NG+CCS fuels consistently cheaper than e-fuel (but not zero)

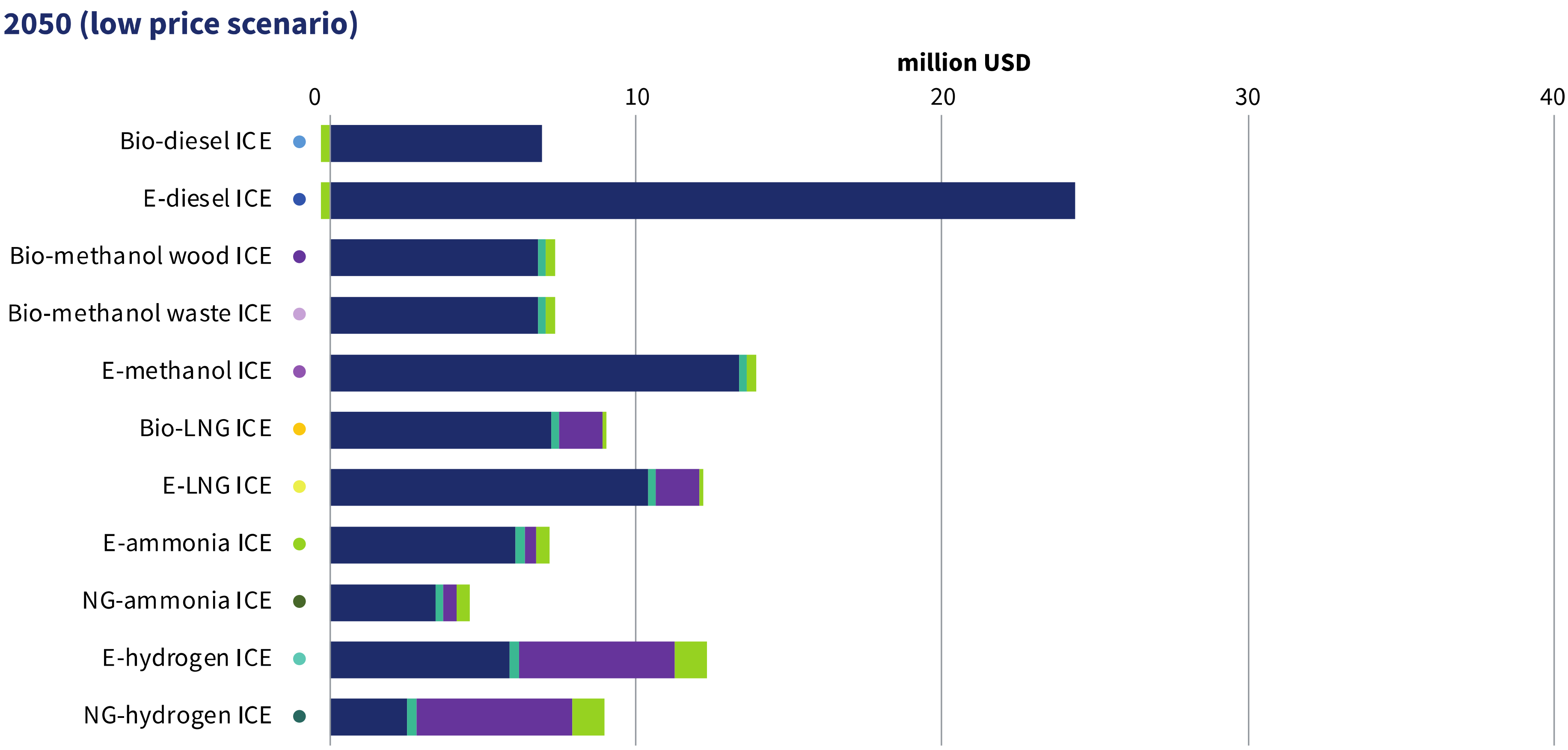
Ammonia consistently cheaper than synth hydrocarbons,

Hydrogen and e-LNG 20-50% more expensive on total cost basis

Ammonia competitiveness improves with time

LR and UMAS, 2020, Techno-economic assessment of zero carbon fuels

Total cost of operation, component costs



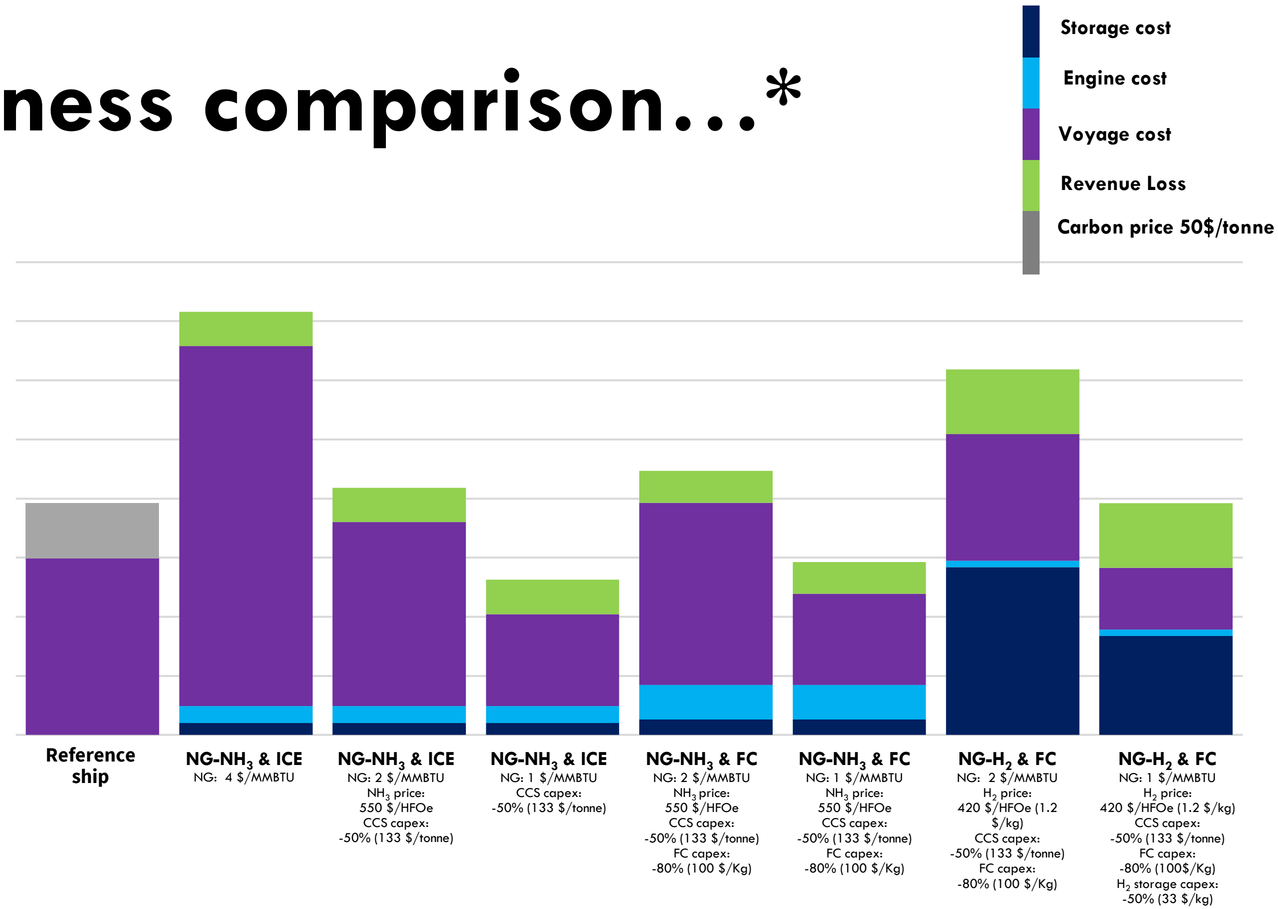
Figures 4a – Relative cost implications of ZEV technologies for bulk carrier under low-price scenario and no carbon price.

LR and UMAS, 2020, Techno-economic assessment of zero carbon fuels

UMAS

Competitiveness comparison…*

- **Price of NG reduces from $ 4/MMBTU to $ 1/MMBTU**
- **CCS capex reduces by 50%**
- **Fuel cell capex reduces by 80%**



**medium-sized bulk carrier, LR UMAS (2017). Zero-Emission Vessels: Transition Pathways*

↑ Higher

↓ Lower

~ Agnostic

	UMAS /LR	IEA ETP 2020	DNV 2020
Convergence:			
– Total cost of operation increase re HFO/LSFO	●	●	●
– Ammonia likely dominant in long-run, but wider emissions and safety needs answers	●	●	●
– Internal combustion likely least cost (but does not mean FC not high potential)	●	●	●
– Shipping likely to need large volumes of low/zero hydrogen (feedstock)	●	●	●
Divergence:			
– Rate of decarbonisation	↑	↓	~
– Sustainable bioenergy avail	↓	↑	↑
– Timescale to transition	↑	↓	~
– Flexibility of different machinery/fuel pathways)	↑	↑	↓

Key drivers variability?	How can we handle them?
Technology cost and efficiency assumptions and their evolution over time	Be transparent on these assumptions, allow ease of comparison

GLOBAL MARITIME FORUM

ENERGY TRANSITION

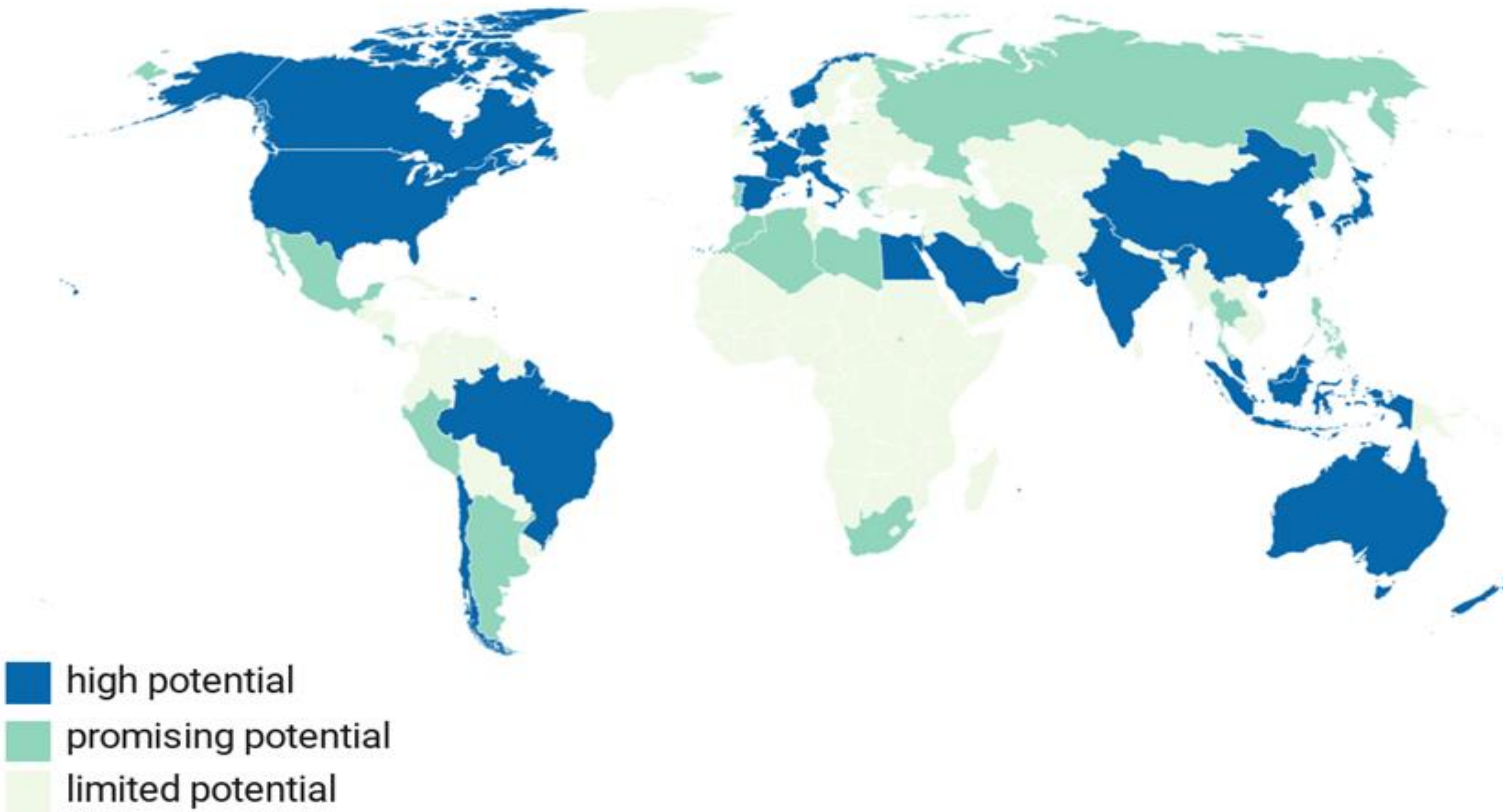
Getting to Zero Coalition

Accelerating maritime shipping's decarbonization with the development and deployment of commercially viable deep sea zero emission vessels by 2030.

How might transition happen?

Where will the hydrogen/ammonia come from?

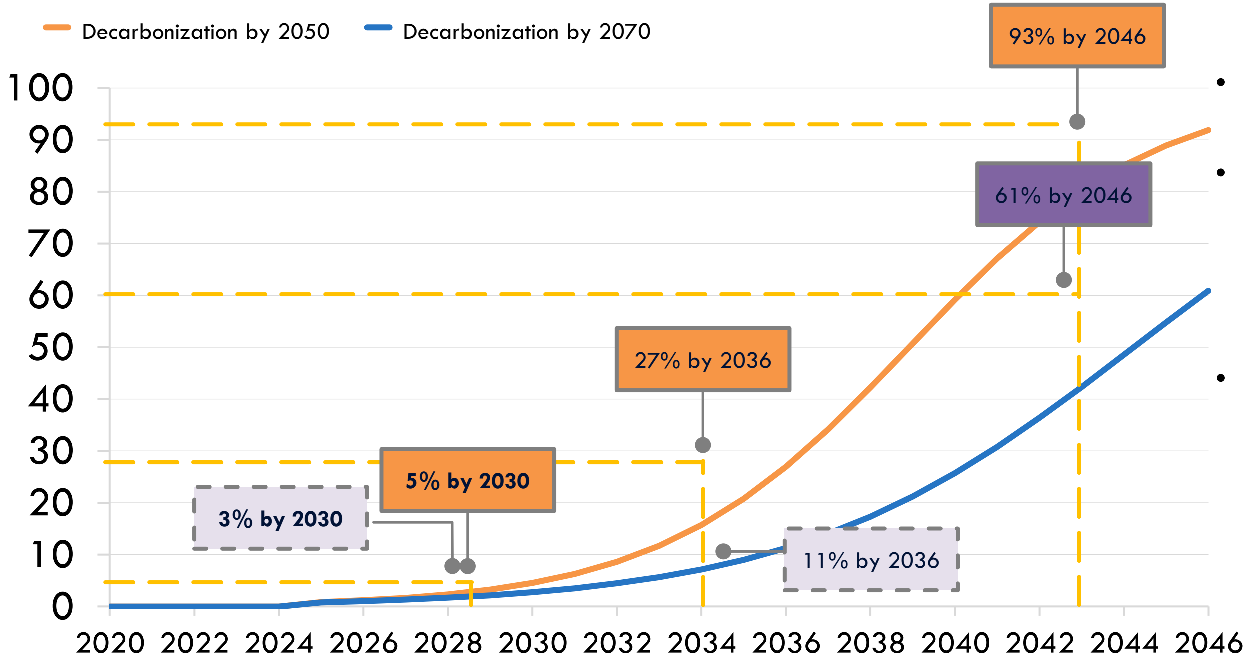
Evaluation of potential for a “first blue then green” hydrogen transition



Forthcoming: WB, UMAS (2020) Role and potential of zero-carbon bunker fuels

Based on this, S-curve modelling implies a need for ~5% of zero emission fuels in international shipping by 2030

Zero emission fuel adoption rate (percent of fuel per year)



- S-curves generated to match UMAS scenarios as closely as possible
- Works well for 1.5C scenario. For IMO scenario the implied increase from 27% to 61% in 2046 cannot be fitted to an S-curve, hence a lower value for 2036 is generated here, 11%
- Curves suggest 3-5% needed by 2030. As the IMO-aligned curve produces a too low result for 2036 (11%) it is likely **best to aim for 5% regardless of scenario**

Forthcoming: COP Climate Champions and UMAS

The "Green Hydrogen Catapult" aims for 25GW by 2025 and reaching $2/kg…

- **Founding members** - Six green hydrogen industry leaders and the Rocky Mountain Institut

YARA
IBERDROLA
Ørsted
ACWA POWER
CWP Renewables
Envision
Rocky Mountain Institute

Target 2026

- To deploy **25 gigawatts** renewables-based hydrogen production, boosting current ambition **2.5x**
- **Halving** the current cost of hydrogen to **below US$2 per kilogram**

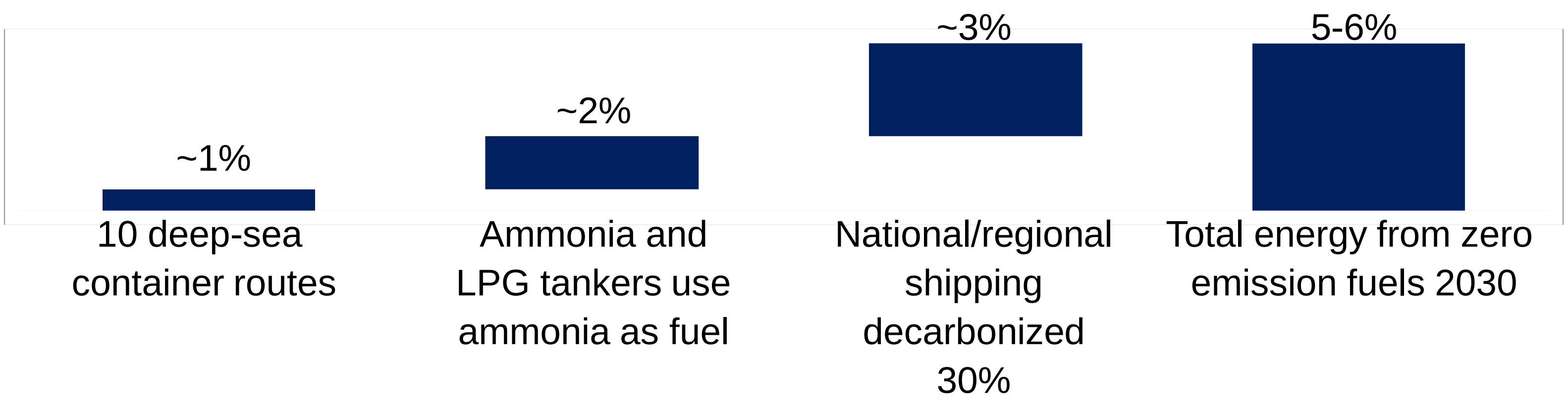
Target 2050

- To align the production and use of green hydrogen with a trajectory that **displaces fossil fuels at a rate consistent with achieving net zero** global emissions by 2050

COP Climate champions

Which ships will want zero carbon fuels?

5% zero-emission fuels in 2030 could be achieved by a combination of container, tanker and domestic shipping



Source: UMAS, 4th IMO GHG Study

National strategy (and industrial strategy) can move faster than IMO

- Commitment on fleet decarbonization
- Commitments on ports/supply chain for fuels/bunkering
- Commitments on finance

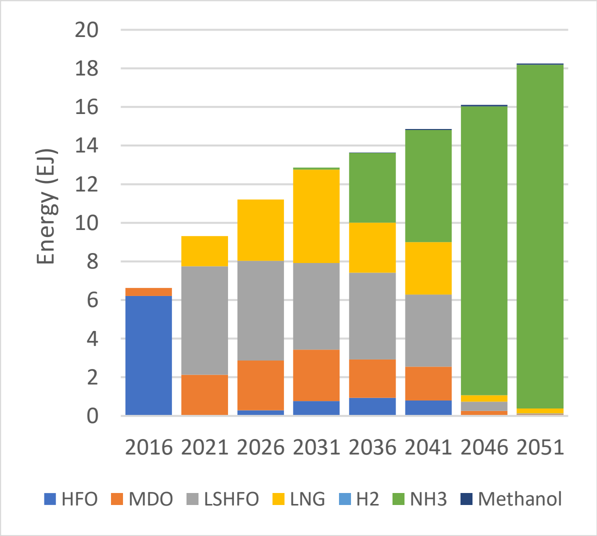
Concluding remarks

- Hydrogen will be needed maybe
  - Hydrogen (compressed liquefied)
  - Ammonia
  - Other
- We are at the learning by doing stage
- Concept design, approval, guidance, pilots etc. critical now
- There are lots of niches and pressures increasing and creating opportunity, let's exploit these

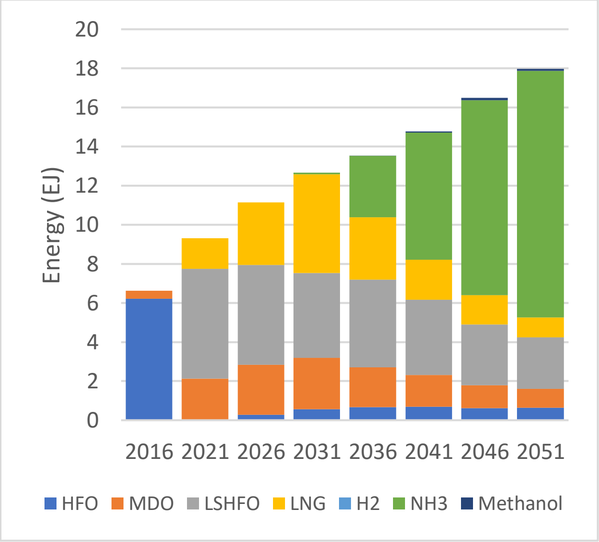
Backup material

Role of LNG – what if we did have an LNG phase and decarbonized?

Zero by 2050



Zero by 2070



- Decarbonisation will likely see retrofitting of existing fleet to zero, as well as zero emission newbuilds
- 2020's built LNG fueled ships are more likely candidates for retrofit to hydrogen/ammonia than older ships – demand for LNG as a marine fuel falls of fast from its peak

Role of LNG – past and present forecast

2020 LNG ~ 1% of fuel mix

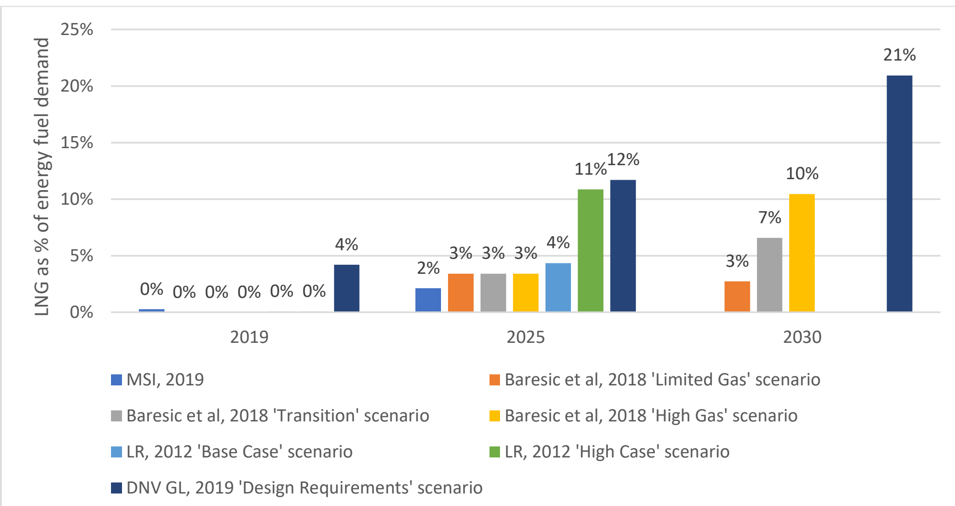
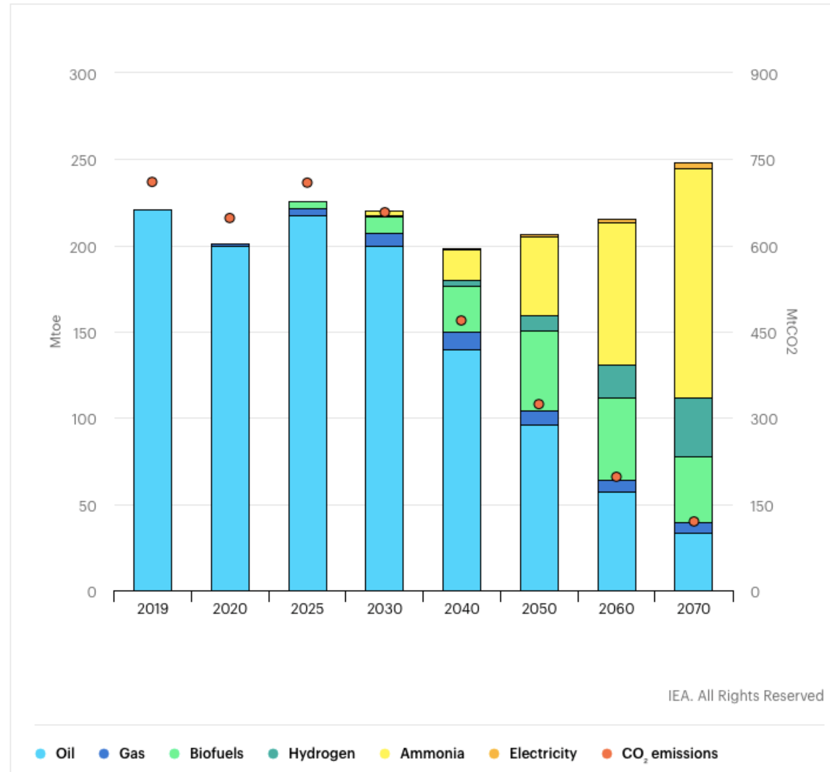


Figure 2: Estimated LNG take up by 2025 and 2030, % of fuel demand[7]

LNG's uptake has a history of optimism

IEA ETP 2020, 2 degrees



The IMO's initial strategy means a move away from fossil fuel, many therefore estimate weak demand growth to 2030 or max 2040, then contraction

Role of LNG is there any GHG benefit?

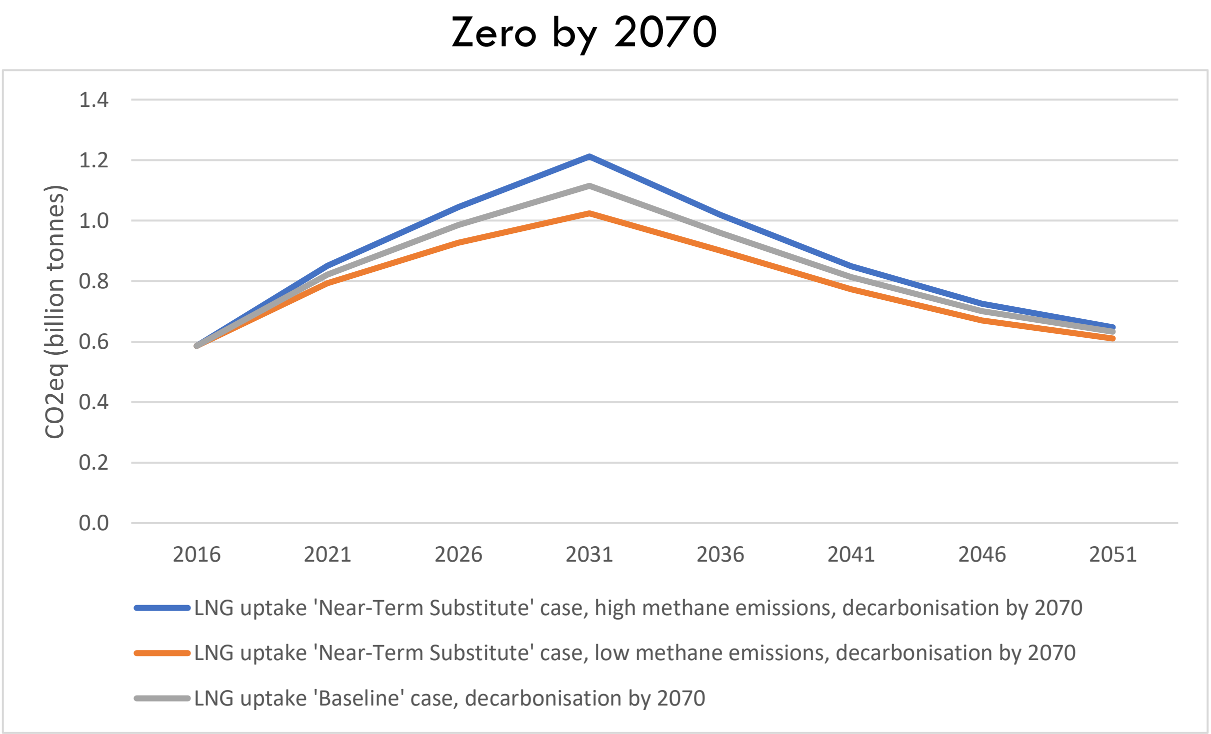
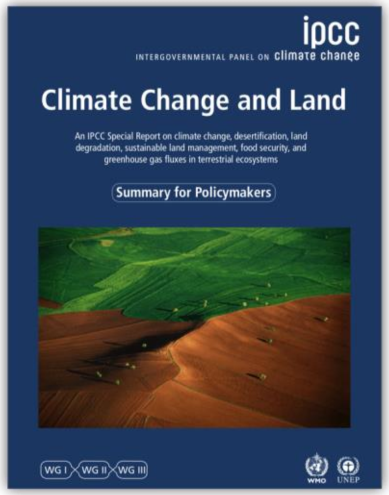
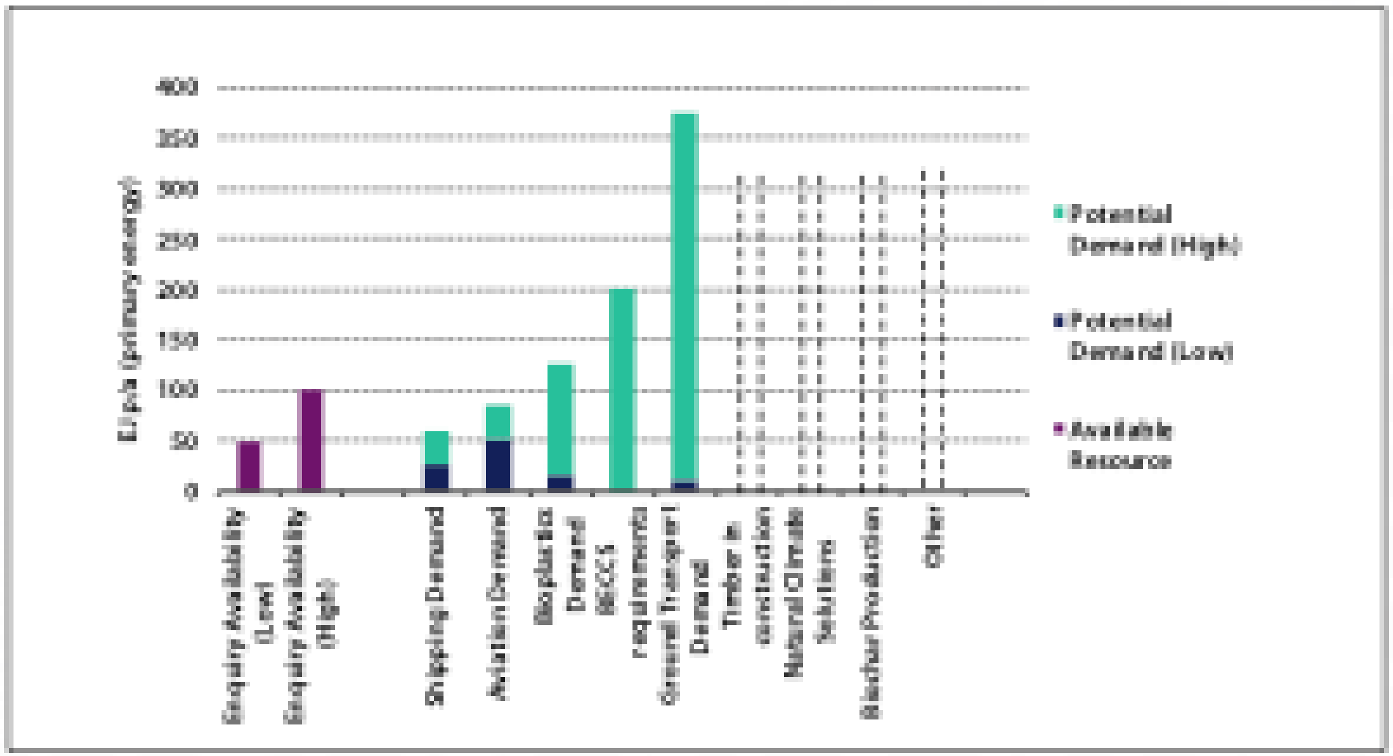


Figure 5: Total lifecycle CO_2eq (including upstream, midstream and downstream emissions). This figure includes the impact of methane leakage using the 100-year GWP of 25.

- Even if 30% of energy demand in 2030 is met LNG, the impact on the GHG trajectory of the fleet is noise. There is no compelling GHG benefit – relative to the scale of the decarbonization challenge the sector faces
- There are greater air quality benefits, but these are also achieved with zero emission fuel/machinery

Bioenergy?





SSI, 2019, The role of sustainable biofuels in the decarbonization of shipping